A business game for offering IT solutions for elderly care homes

Techno-economic evaluation on a Master student level

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***Abstract*— This paper describes a business game developed for a techno-economic project developed for engineering students on a Master level. This project intends to link technical challenges and a competitive business exercise, motivating students to work with the course material in a different way. The project consists of three phases. In the technical design phase, initial service set and network design are chosen. In the business game phase, strategic choices are made by selecting services, networks and pricing schemes. Finally, the evaluation phase concerns a detailed investment plan, reflecting on choices made during the first 2 phases. Students work in teams, requiring a lot of interaction. The interface is an online tool allowing multiple interaction moments. Experience with this project over the last three years showed a huge learning effect. By varying the actual use case the assignment can easily be updated year-over-year. The current paper describes an ICT solution for elderly care homes as the use case under consideration, whereas an ICT solution for schools has been implemented as well.**

Keywords—techno-economic project, ICT solution for elderly care homes, engineering students, business game, educational innovation

I. MOTIVATION

Business games form a popular tool to motivate students and to stimulate their entrepreneurial skills. They are offered by consulting companies as a kind of campus recruitment strategy as well as by teachers to add a competitive aspect to student projects within regular courses.

ServiceSIM [1] is a business game providing a general management expierence, focusses on managing the profitability and customer satisfaction of a service orientated business. This game seeks to provide insights in the drivers of customer satisfaction and the cost trade-offs to maintain it. Strategically thinking is required but there is no technical challenge. Another example is the business game "The Fresh Connection" [2] , which is an interactive web-based business simulation. In this game, the focus lies more on the different tasks that need to be executed within the value chain and hence has a more operational point of view. Professor Duarte developed a business game [3] for the benefit of his Master students in engineering.

In the current paper we describe a business game developed as a student project for an introductory course on information technology and data processing for engineering students without any background in ICT. It intends to link the technical knowledge goals of the course to the business interests of the students. Technical design and pricing decisions are the two key aspects. Financing is considered out of scope. Students work in teams, requiring a lot of interaction. The interface is an online tool allowing multiple interaction moments.

II. GOAL OF THE STUDENT PROJECT

Student teams take the role of IT solution providers for residential care homes. They develop a service offer and make a technical design allowing to implement this offer. The offer should provide IT-supported health, office, security and entertainment services, specifically targeted to elderly people. The project consists of three phases (Fig. 1).

The first phase is the technical design phase, in which each team designs several potential networks based on the technological requirements needed for the offering of the chosen services. The technical design phase includes two parts: the initial service choice indicating which services the team wants to offer as well as the network designs for the care homes that match these requirements. The intention of the first project phase is to get to know the technology and to understand which solutions (combinations of network and services) can be offered.

The second phase is a business game. The intention of this phase is to get to know the (fictitious) market, deal with competition and choose a pricing strategy. The teams will sell an integrated platform (suitable for the different categories of services) to the care homes. Based on their strategic choices, the teams are competing for market share and their ultimate goal is to maximize the profit of their company. Note that the entire project is dealing with a fictitious market where the student teams are the only providers of IT solutions towards the care homes. Actual market players are therefore irrelevant to this project. The game is played via an online tool in several consecutive rounds (one test round to get to know the game and its environment, followed by three cumulative rounds).

In the third phase insights from the first two phases are to be combined in a final investment plan. Based on lessons learned about the services and their costs as well as the business insights (market behavior and revenue potential) obtained during the game phase, choices made during the project should be evaluated and an improved business plan is to be developed.

Note that splitting the project in 3 consecutive phases, allows to reduce its implementation complexity. Technical design is fixed before the start of the business game allowing a round of supervisors' feedback on the network(s) suggested. In case of important flaws in the technical design, a penalty cost will be added in the business game for that team, still ensuring that all teams can start the business game with a well-functioning network. Furthermore, the separate phase for writing out the investment plan adds an additional layer of reflection for the students where they need to bring together insights from technical (cost) and business (pricing and revenue) side.

<table>
<tr><th></th><th></th><th>Initial services</th><th>Network design</th><th>Services selection</th><th>Network selection</th><th>Pricing scheme</th></tr>
<tr><td>Technical Design</td><td></td><td colspan="2">Input</td><td colspan="3"></td></tr>
<tr><td rowspan="4">Business Game</td><td>Test Round</td><td rowspan="4" colspan="2">Fixed</td><td colspan="3">Input</td></tr>
<tr><td>Round 1</td><td colspan="3">Input</td></tr>
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<tr><td>Investment plan</td><td colspan="6">Evaluation</td></tr>
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Fig. 1. The techno-economic student project consists of three phases. In the technical design phase (phase 1), initial service set and network design are chosen. In the business game (phase 2), strategic choices are made by selecting services, networks and pricing schemes. The evaluation phase (phase 3) concerns a detailed investment plan, reflecting on choices made during the first 2 phases.

III. TECHNICAL DESIGN

The goal of the first phase of the project is the technical design of an IT solution for residential care homes. Each student team is expected to develop several technical designs, each consisting of an internal network layout for serving the care home and an associated potential service set. We allow the students to develop 2 till 4 different designs, according to their own preference and strategic choices. Per technical design (= pair of network and potential service set) the following aspects are distinguished: initial service set, technical requirements, network design and cost.

A. Design choices include service set and bill of material

IT services for residential care homes aim at improving the quality of life of elderly people in these homes. Student teams should decide on several (maximum 4) initial service sets. There is no restriction on the amount of services selected per initial service set, as long as the network is able to support them. However, in the business game phase of the project, maximum development budget will put a restriction on the number of services to be developed). There is a broad spectrum of possible services from which the following categories have been selected: entertainment services, office services, health services and security services. A list of potential services is provided to the students (via the online tool), including an indication of the willingness to pay for these services (one up to five stars).

For each initial service set, the students should list the technical requirements for the combination of chosen services. E.g. a service that requires video streaming will only be offered if a minimum effective bandwidth of 3 Mbps per patient room can be provided. In case a website is created, on which the residential care home wants to keep control over the hosting, a webserver is needed.

Next, for each initial service set, a corresponding network should be designed that matches all technical requirements posed by the services in the service set. In other words, the network should be able to offer all services to all users. Furthermore, an end user device (e.g. fixed screen or tablet) should be chosen that matches the service requirements and can easily be connected to the designed network.

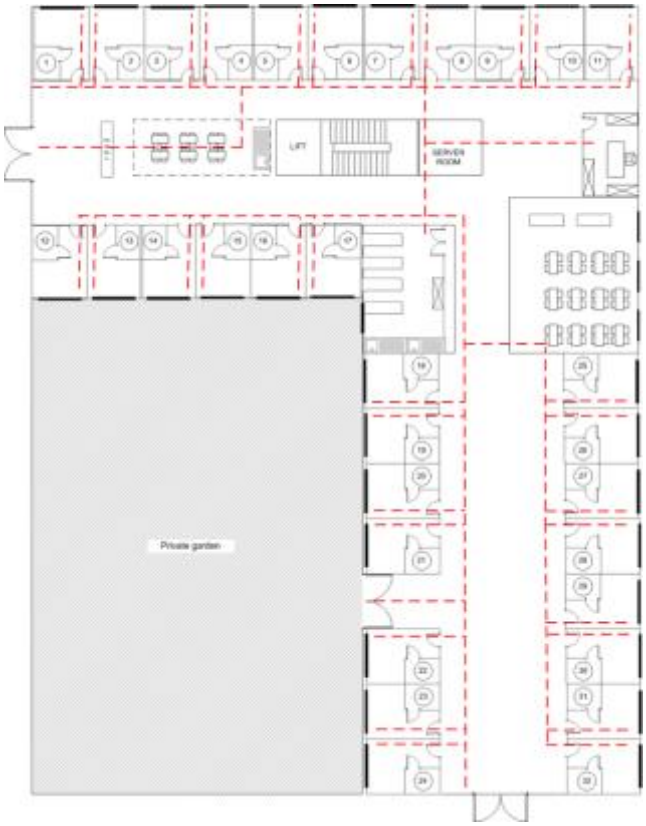

Fig. 2. The standardized floorplan for residential care homes considered in this project consists of 32 patient rooms, a server room, a director's office, cafeteria/eating room, kitchen, nurse bay (having a big screen displaying the status of the different rooms, indicating e.g. patient calls) and reception desk. All rooms are to be connected wired or wirelessly to the internal network, which in turn is to be connected to the Internet (entering the residential care home via the server room).

Students are provided with a floor plan of a hypothetic care home (Fig. 2) as well as with a list of network equipment to be chosen from (including corresponding datasheets and a

reference cost for each component). Potential cable locations and ducts are indicated in the map by red dotted lines.

B. *Additional requirements are security and cost*

A residential care home furthermore puts high value to the security of the network, esp. with respect to the privacy of the inhabitants. At all costs, it would protect patients' personal information from any unauthorized access, either using the public network in the patient rooms or the Internet. Therefore, doctors, nurses and other care takers must have their own (virtual) network. Finally, the management of the care home wants to be able to block all sorts of obscure images and video streaming services, hence a firewall is required. These additional security requirements imposed on the network design require the teams to choose and match the appropriate network devices (VLAN or VPN capable) or to design a physically separate network for staff members. Next to that, students have to explain how they deal with interference on the 2.4 GHz band caused by a microwave oven and what type of cable should be used depending on the required length to be bridged.

Clearly, the cost of the network helps to determine how attractive the resulting offer will be to the residential care homes (as they decide based on a price-quality ratio). Building a network with the most expensive materials is to be avoided when it will only be used to offer services with minimal requirements. On the other hand the use of very cheap equipment (e.g. equipment for home use) will undermine the quality of service, which will result in a lower perceived quality. As such, the decisions on network design involve important trade-offs the students must take into account.

Apart from the network layout and hardware installation, the technical design includes the choice for an end user device. Important here is to choose a device with a good cost-functionality trade-off for the service set and network under consideration. For the sake of simplicity, we assume the same end user device is being used by all patients and therefore installed in all patient rooms. Similar to network equipment, end user devices are to be chosen from a predetermined list, taking into account cost and technical characteristics (from datasheets). Students need to take care about technical compatibility between end user devices and network design. For instance, if the end device is not Bluetooth compatible, services that require this type of connectivity cannot be provided.

The technical design phase results in (a maximum of 4) technical designs as an input in the online tool: network design, equipment list (incl. end user device) and initial service set. A bill of material is required for all network solutions, with an argumentation for the chosen equipment.

IV. BUSINESS GAME AND MARKET MODEL

In the business game the teams represent companies that sell a ready-to-use offer, consisting of an integrated software and hardware package that provides services in the 4 aforementioned categories: entertainment services, office services, health services and security services. The objective of the game is to construct a viable business model for each company (represented by a student team) matching the chosen strategy, e.g. maximal profit, maximal market share, niche market, etc.

Profit can be made by selling the offer to different residential care homes in a simulated market. This market is shared between the competing teams and allocation is based on product differentiation, the latter being based on strategic choices. These choices are the actual "playing" element of the game (to be chosen in every game round). Each round, two offers should be provided per team. An offer consists of a technical design (chosen from the list of maximum 4 designs), a set of services to be offered (chosen from the initial service set defined by the design), and finally the package price charged to the residential care homes (split between upfront and recurring charge). Note that this packet price should cover for the cost of the network, including OpEx, the cost of all end devices and the development cost of the services.

The choices are to be indicated in the online tool by each student team separately. Actual choices are kept secret for the other teams. When the choices for all teams are submitted, the game simulator calculates market share, revenue, cost and profit for each team. The division of the market share amongst the different teams is calculated by the simulator based on a realistic market model [4].

A. *Fictitious market with a realistic size*

The game is played in an artificial market, in which the effects of competition on the real market are reflected. We assume a market of 2000 residential care homes, each housing 32 patient rooms (related to the actual size of the Flemish care home market of 72,000 residents). We assume that one care home subscribes to a package of maximum one IT solution provider and stays loyal to that provider for the entire period of the game (i.e. customer churn is not taken into account). The artificial market follows an S-shaped penetration growth (adoption curve), so the available market will be smaller in the beginning of the game compared to the later stages.

It is clear that not all services are judged to be equally useful or important for residential care homes. Based on market preferences (which were deduced from a survey amongst representatives of several residential care homes in Flanders), we calculated a preference score for each of the services. This preference score (an indicative number of stars for each service) is taken into account when determining the division of the market amongst the different teams.

B. *Market interaction based on segments with specific behavior*

The residential care homes will not simply buy the package with the best services and features (highest package score) but are rather looking for the package with the highest value for money, based on their personal preference and based on the typical preference within the associated market segment. In the fictitious market of the business game, three market segments are defined. These segments behave differently in terms of price elasticity, service category (health, entertainment, security, office) preference and cut-off price (i.e. maximum willingness to pay). The price elasticity and willingness to pay

are again based on the segments in the real Flemish care home market, while the service preferences are based on interviews with care home exploiters of the three segments:

The commercial care homes, as a first segment, represent about 15% of the overall market. As they target the more wealthy elderly, they clearly have the highest budget of all three types, and focus mostly on luxury entertainment and security services. As these homes are frequently built and exploited by different agencies, they will mostly opt for a low upfront investment.

A second segment in the market for residential care homes is publicly owned (about 35%). These homes get allocated a certain IT budget, which is the lowest of all three segments. The recurring fee is very important in their valuation. The main focus lies with the implementation of pure-health oriented services.

The third and last type of residential care homes are owned and operated by non-for-profit organizations (remaining 50% of the market). They have a medium budget and base their subscription decision on both upfront investment and recurring fees. They focus on efficiency improvement.

V. Strategic Student Decisions in the Game

The game is played in a fixed setting: the technical and service choices that each team can make are limited and restricted to the initial list of designs made in phase 1. Prices consist of an upfront and a recurring fee and are assumed uniform per service offer (same price for all care homes subscribing in a certain game round).

Market segmentation should allow student teams to play a specific strategy in the game. They are forced to keep this differentiation in market preferences in mind while determining their strategy, as it might be better to target one specific market instead of gamble on the average in some situations. The goal is to watch competitors closely as the game develops, and try to anticipate their strategy.

A. A Suitable Service Offer

The decision whether or not to include a certain service should be based on the trade-off between added value (whether the market is interested in this service) and additional cost.

Offering a certain service for the first time requires a development cost, independent on the number of subscribers for this service. The maximum available budget to be spent on service development is restricted. In our implementation we set it to €1,500,000 over the duration of the game (3 actual game rounds).

B. Price setting

The actual pricing schemes towards the residential care homes can be determined, based upon up-front payment (lump sum fee per care home), yearly payment (yearly fee per care home) or a combination of both. All prices are per residential care home.

A lump sum fee is paid only once, for the entire lifetime of the offer. It is to be paid upfront, before installing the network and delivering the services to the care home. The yearly fee, on the other hand, is to be paid every year, starting in the year where the residential care home first became a customer till the end of the game. A yearly fee is typically used to cover the operational expenses throughout the entire game duration.

The revenues earned based on this pricing scheme, should allow to cover for the network equipment as well as the operational network cost, any recurring costs for cloud services, the cost of the end devices and the software development cost for the services.

We consider a project horizon of 5 years. Limited lifetime of equipment is not considered. All network equipment is supposed to last throughout the entire lifetime of the project, in order words network equipment is supposed not to fail. On the other hand, operational costs of the network are taken into account. They are estimated at 10% of the yearly cost.

VI. Game Results

The game reports generated by the game simulator are provided to the students after every game round. As in an actual market, only results for current and past periods are displayed. Only at the end of the game (end of period 3) an extrapolation is given towards 5 years, indicating what would happen if all teams would stick to their strategies.

A. Game results are partially confidential

The reports consist of two parts. The first part gives a general market overview (identical in all student reports and hence publicly available for all teams), including cumulative profits, global adoption, market share for the different segments and service quality according to the different services types (entertainment, health, office and security). The second part of the report is specific per team and includes absolute adoption (number of acquired homes per team), direct costs, revenues and profits per offer (so not taking into account the overall development costs), and adoption drive. This adoption drive shows which of the service categories were most important for the care homes to decide to go for this specific offer, split for each market segment. If one team for example would only offer services in one service category, all markets would only base their decision on that category. On the other hand, a 75% market drive for health services and a 25% market drive for security services for one particular market means that, within this market, the care homes value the offered health services three times more than the offered security service.

B. Game reports contain a lot of graphs

In the following paragraphs we introduce some of the results which are provided to the students.

A first graph (Fig. 3) shows the cumulative profits of each group. These cumulative profits equal the summed revenues, decreased by the summed costs. They give a good idea about the financial situation of each company. Furthermore, these cumulative profits (or losses) will be used by our simulator to decide whether the individual company is healthy enough to stay on the market. If a teams' cumulative losses are too high, this team risks bankruptcy and will be removed from the game.

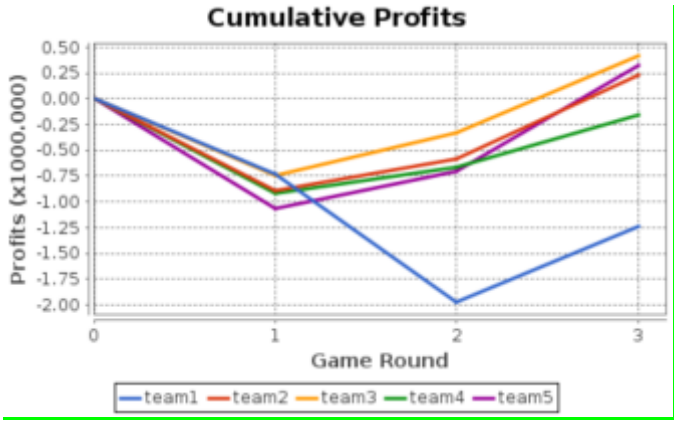

Fig. 3. Exemplary cumulative profits per team per game round show profits for most of the companies in year 3.

A next graph (Fig. 4) provided to all teams shows the division (for a specific market) among the different companies. These graphs thus show which share of the available market any team has appropriated. This graph could and should be used by teams to verify if their strategies work out as planned.

Fig. 4. Exemplary market shares for the public market per team per game round indicate biggest market share for team 3 over all periods.

A last example graph (Fig. 5) represents the average cost, revenue and profit for an offer per game round, and is, in comparison to the previous graphs, part of the "private" section of the report. The average is always calculated based on the sales made in the considered game round (not taking into account sales made in prior periods). It furthermore only represents direct sales, meaning that the offer only takes into account direct costs and direct revenues (the development cost for the services for example is not included). Based upon this chart, teams can verify the pricing margin of their offer.

As mentioned earlier, the game results provided to the students are not limited to the ones discussed in the previous paragraphs, other results include global market adoption, adoption of each offer per market and offer quality relative to other teams. The combination of all graphs should provide the students with sufficient (quantitative) feedback on their results, so that their strategy can be adjusted after each period.

Fig. 5. Exemplary cost, revenue and profit overview of a team's offer allow to verify the profitability of an individual offer.

VII. Investment Plan

The insights from the first two project phases are to be combined in the final investment plan in phase 3. This phase leans on the lessons learned from the first two phases of the project, and should therefore also reflect each team's experiences. In this phase, the strategic decisions taken in the technical design and business phase should be economically evaluated. Each team should include a full economic investment analysis, providing acquired business insights, i.e. how much market share is needed to survive, what profit margins are aimed for, etc.

Students are asked to give a quantitative NPV analysis for 5 years, with a range of different discount rates (0, 5, 10%) so that they can clearly see the impact thereof. Next to that, they are also asked to make a qualitative impact assessment of their strategies. On the one hand side this includes indicating the expected impact of future decisions: if the business game were to continue for more years, what would be the next strategic choices? On the other hand side, also the impact of an entirely new strategy is to be evaluated. When playing the business game again from start, what would be the new strategy, and most importantly, why?

VIII. Interaction with the Students and Learning Effect

This student project requires active participation throughout the semester, as there are several consecutive submission moments. Also supervisor feedback is needed at several points in time in order to maximize the learning effect.

A. *Student Deliverables*

The choices in phase 1 (network design and initial service set) and 2 (actual service offer and pricing) are submitted via the online tool. See also the network layout template in Fig. 2 and screenshot examples in Fig. 6. and Fig. 7.

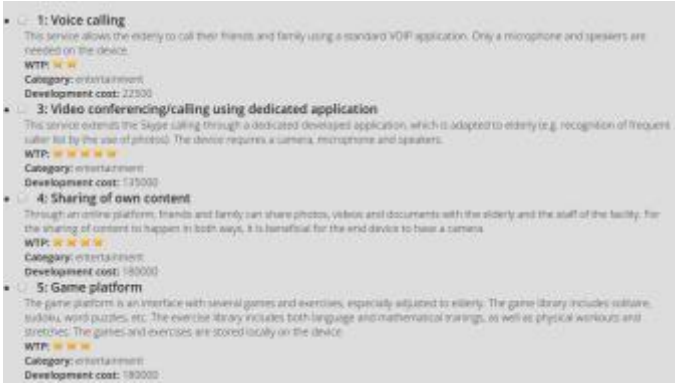

Fig. 6. A screenshot from the online tool indicating a (limited) list of possible services the companies can offer.

Period: 1	Offer:1	Offer:2
Services	14: Assistance call system 16: agenda 18: PAS: Personal Alarm System button 27: GPS tracking with alert 28: Centralized control of devices 32: Security control	14: Assistance call system 21: Telemedicine monitoring - discrete 25: Shared care file 27: GPS tracking with alert 32: Security control
Selected Network	Network 2	Network 3
Upfront fee	64730	58939
Yearly fee	11700	5159

Fig. 7. A screenshot from the online tool indicating that a textual overview allows the students to verify their input for both offers per game round.

Written reporting is required from the students after the technical design phase as well as at the end of the project. Reports should include an argumentation of the choices made and an analysis of the results obtained. Finally, at the end of the semester, after submitting the final report, a per-team presentation is to be given. Ideally, this presentation takes the form of a short pitch of the suggested IT-solution (chosen technology, services and prices).

B. *Supervisors' Interaction*

We strongly believe that the interactive set-up of the project, including different feedback moments, adds positively to the learning effect of the project. Student feedback from previous editions indicates that students indeed value this type of working.

The technical report, describing and motivating all technical choices (at the end of phase 1) should be submitted twice. The preliminary submission is reviewed by the supervisors of the project, after which the student teams are invited for a feedback session (each group separately). This feedback allows groups to remove any mistakes in the design so that all can start the actual business game (phase 2) with well-functioning technical designs. Remaining mistakes in the second version of the technical design result in a penalty cost for the business game.

The business game itself consists of three actual game rounds, each followed by a feedback report indicating how the different student teams perform on the market (see section VI on Game Results). Before the start of the actual game, there is a test round, allowing students to get to know the market reactions. The market is reset after this test round, so that all teams can start fresh at the first actual game round.

In a project manual provided to the students, it is stated that supervisors have the option to kick a student team out of the game when the latter sets unrealistically low prices, which could disrupt the market interaction. In real world it would eventually lead to bankruptcy.

In the three editions of the project up till now the described type of feedback and interaction worked fine and no drastic decisions had to be made: no team had to be excluded from the game.

C. *Peer Evaluation*

The project teams consist of 4, 5 or 6 team members, depending on the size of the student group subscribing to the course. Typically we have a broad influx of domestic as well as international students with different Bachelor degrees. Student teams are intentionally composed heterogeneously.

As diverse backgrounds sometimes lead to tensions amongst group members, we foresee an intra-group peer evaluation, where students can evaluate the contribution of the other team members to the project. This is done anonymously, so that students do not know how they have been rated by other team members. Students are asked to submit this peer evaluation before the final team presentations, allowing the supervisors for instance to direct questions to those team members evaluated poorly by their fellow team members.

IX. Guidelines and Lessons Learned

A business game has been developed for a techno-economic project on a Master level for engineering students. This project brings together technical challenges and a competitive business exercise, motivating students to work with the course material in a different way.

An in-house developed game simulator and online user interface gives a lot of flexibility to the supervisors to update the project year-over-year. The technical design part can easily be kept up to date, minimally by updating the list of hardware devices to choose from. Also market parameters can be updated at wish. Finally, an entirely new use case can be implemented using the existing framework. Up till now we have experience with both an ICT solution for elderly care homes and an ICT solution for schools.

Developing and maintaining this project requires quite some effort of the supervisors. Yearly updates are needed (although they can remain limited). In some cases resources for educational innovation can be used for this purpose. Furthermore, also the effort needed from the student participating in this game is substantial. However, the learning effect is huge and the motivation of the students typically is higher than for more traditional kinds of projects.

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